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A Comprehensive Study of Electric Vehicle Components, Applications, Limiting Factor and Protocols

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Abstract: For the green transportation tool, EV great attraction from researchers, leading of extensive works. With the building of high-storage battery and EV, the more number of the EV will increases, because of that the simultaneously charging and discharging characteristics will gives new challenges to safe and stable. This paper introduces briefly some concepts of EV, including studies on EV, Components, Power required to move vehicle, Limiting Factors, Application, Types of EV Battery, and Protocols for EV Application.
Keywords: Electric Vehicle (EV), Limiting Factors, Application, Protocols for EV Application.

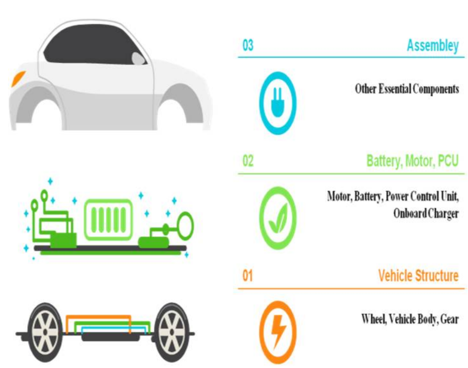
I. INTRODUCTION

Energy and environment are the two important challenges facing the development of human civilization in the earlier days. In recent days, fuel prices rising continuously, variations is also becoming rising the environmental protection of public thoughts is constantly increasing, the related rolls and regulations increasingly strict, "energy saving" and "emission reduction" has a fast realistic problem. Therefore, building new technology to reduce energy consumption and emissions has become an important direction of the building of automobile modern technology, the EV to achieve zero emissions and low fuel consumption, discussed about.

II. LITERATURE REVIEW

1) This paper aims to inform the debate over how electric vehicle technology could be the lower-carbon 2020–2030 new vehicle fleet in Europe by collecting, analyzing, and aggregating the available research literature on the underlying method costs and carbon emissions.
2) The current literature on plug-in electric vehicles (PEVs) with a focus on issues and solutions related to vehicle deployment and integration with the electrical grid.
3) Estimated that 30% of the total cars across the world will run on electricity by 2026. An important component that is an integral part of all electric vehicles is the motor. The amount of torque that the driving motor delivers is what plays a decisive role in determining the speed, acceleration and performance of an electric vehicle.

III. ELECTRIC VEHICLE COMPONENTS



EV Components

The important components of an Electric Vehicle:

A. Inverter
This converts direct current (DC) electricity, to alternating current (AC) electricity known inverter.

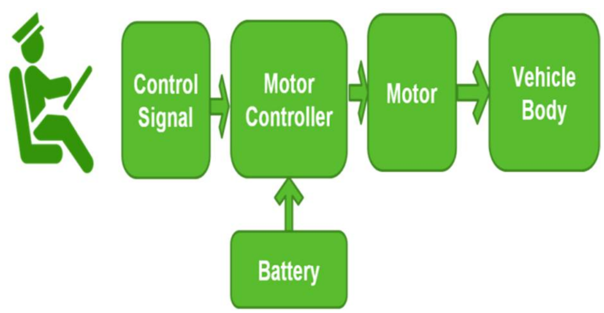
B. Motor
It is an electrical machine that converts electrical energy into mechanical energy.

C. Body
It is is an important part of an EV it will gives the shape and size to the EV.

D. Power Grids for EVs
A Power grids for EVs, also called as EV charger point or electric vehicle supply equipment (EVSE), is supplies electrical power for charging plug-in electric vehicles On Board Charger.

E. Battery Bank
A battery bank is the joining two or more batteries together for a single source. The parameters battery are voltage, or the Capacity (AH / Wh), or both.

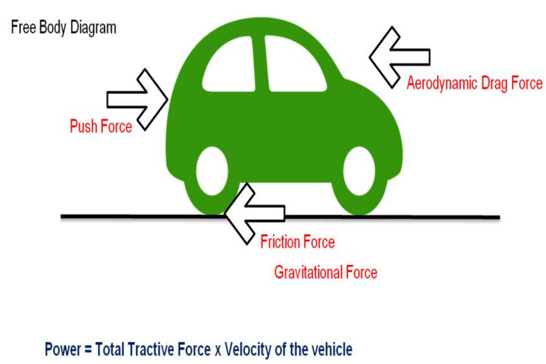
F. Block Diagram



EV block diagram

Above diagram shows the block diagram of an EV. It contains five blocks, the control signal block will gives the signal to the motor controller and also this controller connected to the battery to get the supply. The output of the controller is connected to the motor so the motor will drives the Electric Vehicle through the transmission rod

G. Power Required Move Vehicle



Power required to move vehicle

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IV. FORCES ON THE VEHICLE

Total Tractive Force

1) Rolling Resistance Force (F_{rr})
2) Aerodynamic drag force (F_{aero})
3) Hill climbing Force (F_{hc})
4) Acceleration Force (F_{xi})

A. Linear Acceleration Force

B. Angular acceleration force

1) Rolling Resistance Force

The forces that act on the motion of a vehicle The Coefficient, is functions of the Tire, structure, temperature, pressure, and tread geometry, road roughness, material, presence & absence of liquids on the road.

a) This value varies with SPEED.
b) Tire pressure increases its value decreases

$F_{rr} = \mu_{rr}$ m.g

- μ_{rr} - Rolling Resistance Constant
- m - Mass of the Vehicle
- g - Gravitational acceleration constant

2) Aerodynamic Drag Force

The force of an object that limits its motion through a air is called drag. Drag is a force that effects parallel to and in the same direction as the airflow. Aerodynamic drag increases with the square of speed.

$F_{ad} = ½ \rho C_d A v^2$ Newtons

ρ – Air Density kg/m^3

A – Frontal Area m^2

C_d – Drag Coefficient

v - Velocity of the Vehicle m/s

Drag Coefficient Cd (0.3 - 0.7)

Drag is a force that acts parallel to and in the same direction as the airflow. Aerodynamic drag increases with the square of speed.

Trucks Road Trains- 0.8 - 1.5

Buses -0.6 - 0.7

Modified Buses-0.3 - 0.4

Motorcycles 0.6 - 0.7

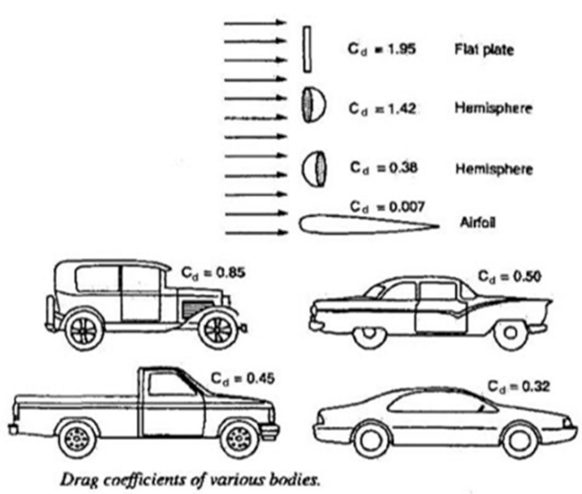

Fig.4.Drag Coefficient

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3) Hill Climbing Force

Rise / Run
Fhc = m.g.Sin θ
= 5' Rise /25' Run * 100
= 20% Safe Design

Total Power Required
Total Power $P = F_{te} . v$
F_{te} Total Tractive Power $= F_{rr} + F_{ad} + F_{hc} + F_{la} + F_{wa}$
Rolling Resistance Force Frr = µrr m.g
µrr - Rolling Resistance Constant
m - Mass of the Vehicle
g - Gravitational acceleration constant
Aerodynamic Drag Force
Fad = ½ ρ Cd A v2 Newton
ρ – Air Density kg/m3
A – Frontal Area m2
Cd – Drag Coefficient
v - Velocity of the Vehicle m/s
Hill Climbing Force Fhc = m.g.Sin θ
Frr - Rolling Resistance Force
Fad – Aerodynamic Drag Force
Fhc - Hill Climbing Force
Fla - Linear Acceleration Force
Fwa - Angular Acceleration Force

4) Linear Acceleration Force (Fla) =m.a

Angular Acceleration Force

$$F_{\omega a} = \frac{IG^2\, a}{r^2\, \eta_q}$$

I=moment of inertia
G=gear ratio
a = acceleration
r = radius of tire
nq =efficiency of gear

V. HOW FAST CAN VEHICLE REACH THE TOP SPEED

A. Limiting Factors I

1) Weight of Vehicle
2) Motor Power of Vehicle

B. Limiting Factors II

1) The Drive wheels will spin on the ground if, tractive effort greater then adhesive capability between tire and ground
2) Significant Slipping on the wet ground, ice, snow covered or smooth soil.
3) Irrespective of the maximum torque power train can apply on wheel
4) Slip S (Tire) = (1 – V/rω) * 100% for running
5) Slip S (Tire) = (1 – rω/V) * 100% For Breaking
6) V is Translatory Speed of Tire midpoint, w Angular speed of tire,
7) r is the Rolling radius of the tire

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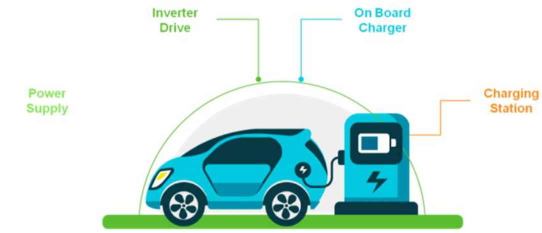
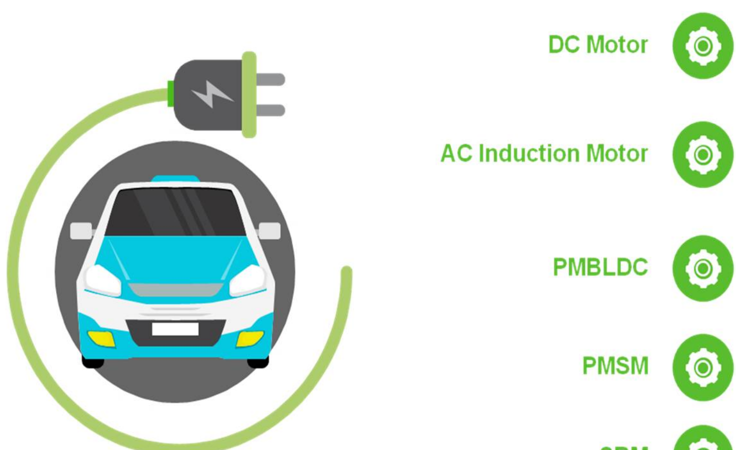
VI. APPLICATION OF POWER ELECTRONICS CONVERTERS IN ELECTRIC VEHICLE



1) Bidirectional Converter Topologies for Plug-In Electric Vehicles
2) Bidirectional Battery Charger for an Electric Vehicle
3) Bidirectional DC–DC Converter for Ultra-Capacitor Applications
4) Integrated Bidirectional Converters for Plug-In HEV Applications
5) Direct Conversion of an AC–DC Converter for Plug-In Hybrid Vehicles
6) Resonant Converter for a Bidirectional EV Charger
7) Isolated Bidirectional AC–DC Converter for a DC Distribution System
8) Bidirectional T-Type Converter Topology for EV Applications
9) Multilevel Two-Quadrant Converter for Regenerative Braking
10) Multiphase Integrated On-board Charger for Electric Vehicles
11) Split Converter-Fed Induction Motor/BLDC/SRM Drive for Flexible Charging in EV and HEV Applications
12) Wireless Topology for EV Battery Charging

VII. MOTORS FOR EV APPLICATION



Factors to choose Electric Motors for EV
1) Electric Vehicle characteristics
2) Driving Wheels
3) Vehicle features
4) Maximal speed Electric Vehicle
5) Maximal torque Motors
6) Maximal power Motors
7) Battery Capacity
8) Battery Voltage
9) Gearbox or direct-drive
10) Cost Electric Vehicle

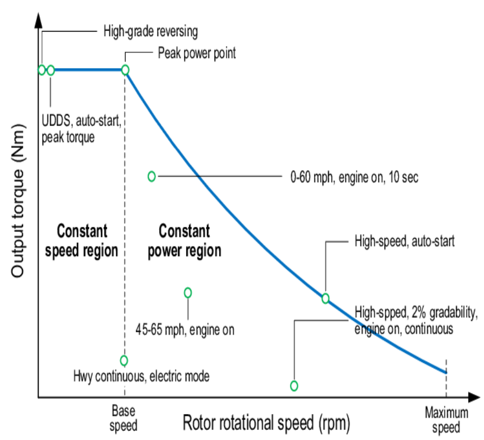
VIII. PURPOSE OF CONTROLLER

1) Starting for electric motor
2) Stopping for electric motor
3) Reversing the rotation of motor
4) Running the motor
5) Speed Control for motor
6) Safety of Operator of motor
7) Protection from Damage

A. *Different Motor Controller*

1) Motor Starters
2) Reduced Voltage controller
3) Adjustable Drives
4) Integrated Controllers
5) Servo Controllers

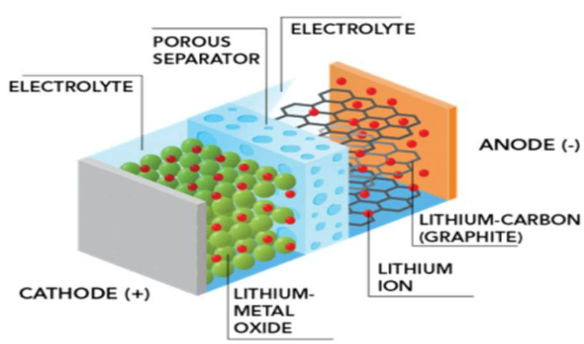
B. *Motor Operating Region*



Motor Operating Region

IX. TYPES OF BATTERIES FOR EV APPLICATIONS

1) Lithium-ion
2) Lithium Phosphate
3) Nickel-metal batteries
4) Lead-acid batteries



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A. Battery Parameters

1) Battery State of Charge (SoC)
2) Depth of Discharge
3) State of Health
4) C - Rate
5) Terminal Voltage
6) Open Circuit Voltage
7) Internal Resistance
8) Life Cycle

B. Battery SoC:

The total energy or battery capacity that has been used over the total available from of the battery. Shows the remaining capacity of the battery while in use.

C. DoD

% capacity of the Battery which has been discharged relative to the overall ideal capacity of the battery.
Note: The Bat should never get full charge or discharge. 20% discharge is the minimum level. 100% Charge.

D. State of Health

Measurement of a battery ability to store and deliver electrical energy

E. Battery Calculations (Example)

Total Power for 40km/Hr	1,890.530
Total Power for 50km/Hr	2,544.010
Total Power for 100km/Hr	8,102.110

Vehicle Details	Value	Units
Weight	1000	Kg
Width	1.0	m
Hieght	1.5	m

Motor Power : 10KW

<u>Step #1 Current Consumption by Motor</u>

P = V x I

I = 10KW/72V

Current required to run full load by the Motor 139 Amps

<u>Step #2 Watt-Hour Calculation</u>

Assume Running Time 1 Hour

P = 10000 x 1 Watt-Hr

<u>Step #3 Ampere Hour Calculation</u>

The Source must have 20-30% more than the required energy
Assume : 20%
Watt-Hr = 10000 x 1.2 = 12000
Ampere Hr = Watt-Hr/Battery Terminal Voltage
= 12000/72
= 166.67Ah

<u>Battery Rating</u>

72V, 166.67Ah
Note:
Hill climbing and angular forces are not considered
The vehicle will cover 100km and balance 20km's energy will be available

X. PROTOCOLS FOR EV APPLICATION

1) EV subsystem
2) Basic Communication system
3) Parameters of Communications
4) Types of Communication
5) Protocols & its Types
6) Vehicle Networking
7) Protocols for EV Charging Industry

A. Types of Protocols

1) Data Link Protocols UART/SPI/IIC/LIN/CAN/Flex-Ray/Ethernet
2) Application Protocols
3) UDS/J1939/CAN-Open/MOST
4) Others
5) Bluetooth/Wi-Fi/USB/4G/5G/V2G

XI. COMMUNICATION TECHNOLOGY USED IN EVS

1) Wired Technolog
2) Wireless Technology

A. Wired Technology

1) Local Interconnect Network (LIN)
2) 1998 invented by consortium of Automotive Industry (Audi, BMW,Daimler-Chrysler, Volcano,Volvo,Volkswegan & Motorola)
3) Standardized Open Source Network
4) 2001 – LIN-1.1 , 2003 – LIN-2.
5) Inexpensive Network Speed up to 2KBps
6) 1 wire system
7) Generally used in Body and Comfort Subsystem and further with CAN/LIN Gateway

B. CAN – Controlled Area Network

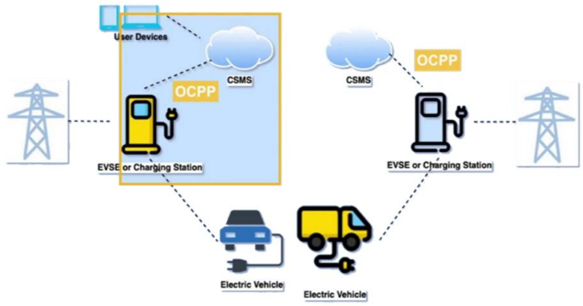
1) 1980s Bosh released CAN Protocol to the world
2) ISO 11898 the most used field bus in the European automobile industry.
3) 150Kbps
4) Broadcast type protocol, 2 wire system Byte flight
5) 1996 – BMW

C. Safe-by-Wire

for airbag control Master/slave network mainly used

D. Protocols for EV Charging Industry

EV charging industry standards and protocols which deliver the flexibility that is needed for the entire electric vehicle market and will be a key enabler of future EV charging infrastructure developments.



E. EV Charger Standards

Type	Connection	Power (kW)	Max current
Europe	1-Phase AC	3.7	16 to 20
	1 or 3 Phase AC	3.7 to 22	16 to 32
	3-Phase AC	>22	>32
	DC Fast	>22	>32
USA	AC Level-1	1.44	12
	AC Level-2	7.7	32
	DC Fast	240	400

F. EV Charger Standards (India)

CHARGER TYPE	CHARGER CONNECTORS*	RATED VOLTAGE	NO. OF CONNECTOR GUNS	VEHICLE TYPE
Fast	CCS (MIN 50 KW)	200–750 or higher	1	4W
	CHADEMO (MIN 50 KW)	200–750 or higher	1	4W
	TYPE-2 AC (MIN 22 KW)	380–415	1	4W, 3W, 2W
Slow/moderate	BHARAT DC-001 (15 KW)	48	1	4W, 3W, 2W
	BHARAT DC-001 (15 KW)	72 or higher	1	4W
	BHARAT AC-001 (10 KW)	230	3; 3.3 kW each	4W, 3W, 2W

EV Charger Standards (India)

XII. CONCLUSION

In this paper author discussed about Electrical vehicle, including studies on EV, Components, Power required to move vehicle, Limiting Factors, Application, Types of EV Battery, Protocols for EV Application. and also In this paper author discussed about the motor for EV, types of batteries used for EV, and also discussed about Protocols for EV Charging industries. And finally author will conclude that pure EV has become one of the most attractive solutions for energy saving and emission reduction.

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